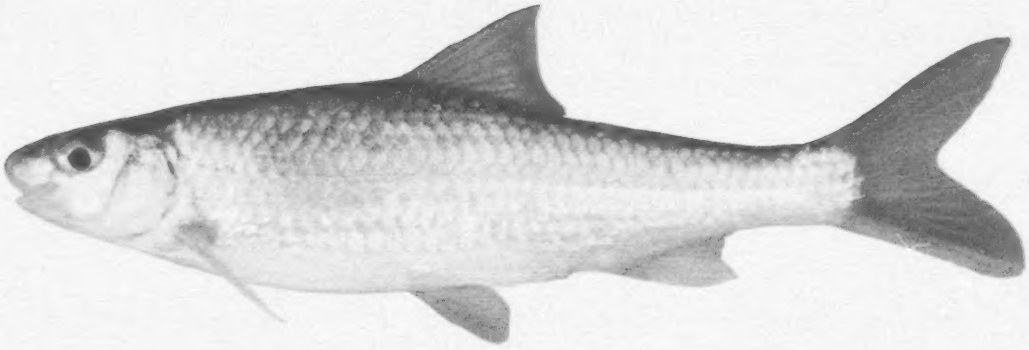
COSEWIC
Assessment and Status Report

on the

Silver Chub
Macrhybopsis storeriana

Great Lakes - Upper St. Lawrence populations
Saskatchewan - Nelson River populations

in Canada



Great Lakes - Upper St. Lawrence populations - ENDANGERED
Saskatchewan - Nelson River populations - NOT AT RISK
2012

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Silver Chub — Photo collected from Assiniboine River, Manitoba. D.A. Watkinson photo.

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COSEWIC
Assessment Summary

Assessment Summary – May 2012

Common name
Silver Chub - Great Lakes - Upper St. Lawrence populations

Scientific name
Macrhybopsis storeriana

Status
Endangered

Reason for designation
This small-bodied fish is native to the middle Great Lakes and has a small distribution range in Canada. Its abundance has declined substantially over the past ten years. Moreover, the longest consecutive time series of lowest abundance has been observed over the last five years. The species is assessed at high risk of extirpation from several threats including habitat degradation, competition with invasive exotic species, and climate change. This species is considered at risk in several border states, including Michigan and New York.

Occurrence
Ontario

Status history
The species was considered a single unit and designated Special Concern in April 1985. Status re-examined and confirmed in May 2001. Split into two populations in May 2012. The "Great Lakes - Upper St. Lawrence populations" unit was designated Endangered in May 2012.

Assessment Summary – May 2012

Common name
Silver Chub - Saskatchewan - Nelson River populations

Scientific name
Macrhybopsis storeriana

Status
Not at Risk

Reason for designation
This small-bodied fish inhabits rivers and lakes in the Saskatchewan-Nelson watershed. There is no evidence of decline in abundance or range, and recent sampling suggests that this is a widespread species, but one which is not particularly abundant anywhere in the watershed.

Occurrence
Manitoba

Status history
The species was considered a single unit and designated Special Concern in April 1985. Status re-examined and confirmed in May 2001. Split into two populations in May 2012. The "Saskatchewan - Nelson River populations" unit was designated Not at Risk in May 2012.

COSEWIC
Executive Summary

Silver Chub
Macrhybopsis storeriana

Great Lakes - Upper St. Lawrence populations
Saskatchewan - Nelson River populations

Wildlife Species Description and Significance

The Silver Chub (*Macrhybopsis storeriana*) is characterized by the presence of a slender barbel at the corners of the mouth, a rounded snout that greatly overhangs the mouth, a large eye on the upper half of the head, fewer than 50 lateral line scales, silvery sides lacking markings and an anteriorly located dorsal fin. It reaches a maximum length of 231 mm total length.

The Silver Chub is the only species of the genus *Macrhybopsis* in Canada. The Great Lakes and Lake Winnipeg drainage populations are geographically isolated from one another and other Silver Chub populations and could be genetically distinct. A loss of either one of these populations would result in an extensive gap in the range of this species in Canada.

Distribution

The range of the Silver Chub extends from Lake Winnipeg and the southern Great Lakes basin south to the Gulf of Mexico. In the Great Lakes basin, the species is limited to lakes Erie and St. Clair, and the extreme southern portion of Lake Huron. In the Lake Winnipeg drainage, it is found in southern Lake Winnipeg and in the Assiniboine and Red river drainages of Manitoba, North and South Dakota, and Minnesota. The Silver Chub occurs in the Mississippi River system from Minnesota south to the Gulf of Mexico. An isolated population also exists in the Brazos River drainage of Texas.

Habitat

In Ontario, the species is found in large lakes and connecting rivers at depths of 7.6–20 m. In Manitoba, it is found primarily in large turbid rivers with moderate (not turbulent) flow, at depths of 0.3–4.2 m. The substrate is usually silt or sand but it is sometimes found on a hard substrate of gravel, rubble, boulder, or bedrock. It is usually not associated with aquatic vegetation.

Biology

The reproduction of Silver Chub is poorly known. In Lake Erie, it leaves open waters and moves into nearshore areas in early spring presumably to spawn. Spawning occurs at temperatures of 19–23°C. Individuals mature at age 1 and reach a maximum age of 4. Fecundity can be as high as 12,311 eggs. The Silver Chub is a bottom feeder that uses taste and sight to obtain its food. Historically, in Lake Erie, young Silver Chub fed on small crustaceans and insect larvae, and older individuals fed primarily on *Hexagenia* mayfly nymphs. More recently, in Lake Erie, Silver Chub prefer feeding on zebra and quagga mussels rather than mayfly nymphs.

Population Sizes and Trends

In Lake Erie, a dramatic decline in the Silver Chub began in the late 1940s. Silver Chub began reappearing in Ontario Ministry of Natural Resources (OMNR) mid-water trawls and bottom gillnets in 1967. Abundances increased gradually to the mid-1990s, then increased dramatically by the late 1990s, and have since fallen precipitously during the 2000s. In Lake St. Clair, Silver Chub has been collected since 1968. Abundance increased until 1979, then declined to 1994—when the last known record was taken from Lake St. Clair.

In Manitoba, the Silver Chub has been collected in the Assiniboine and Red River drainages, and the Lake Winnipeg drainage. Abundance in the Assiniboine and Red rivers appears to be stable and it was often collected in large numbers in the 1990s and, more recently, in directed survey for Silver Chub in 2009. Sampling conducted in the 2000s has substantially increased the known distribution as a result of increased sampling effort and improved gear. Pelagic trawling surveys of Lake Winnipeg conducted annually since 2002 have not detected Silver Chub.

Threats and Limiting Factors

Factors limiting the abundance of Silver Chub include habitat degradation, water temperature, sediment and nutrient loadings, oxygen levels, food, predators, and exotic species. Although the Silver Chub has been recorded from turbid rivers, it moves into clearer water and gravelly substrates when pools became excessively silted. Eutrophication and its effects on water quality, such as low oxygen levels, and on the invertebrate food supply are likely related to the perceived near extirpation of Silver Chub in Lake Erie in the 1960s.

Protection, Status, and Ranks

The Silver Chub is listed as Special Concern under the province of Ontario's *Endangered Species Act, 2007* and Canada's *Species at Risk Act* (Schedule 1). Several Canadian and provincial acts protect aquatic species and habitats in general. The following ranks apply to Silver Chub: Globally secure (G5); nationally in Canada Vulnerable (N3); in Ontario it is Imperiled (S2); and, in Manitoba Vulnerable (S3). It is considered a species of Special Concern by the OMNR (NHIC 2010). The Committee on the Status of Endangered Wildlife in Canada considered it a single unit and designated it Special Concern in April 1985. The status was re-examined and confirmed in May 2001. In May 2012, the "Great Lakes - Upper St. Lawrence populations" unit was designated Endangered in May 2012 and the "Saskatchewan - Nelson River populations" unit was designated Not at Risk.

TECHNICAL SUMMARY – DU1

Macrhybopsis storeriana
Silver Chub — Méné à grandes écailles
Great Lakes-Upper St. Lawrence population — Population des Grands Lacs et du haut Saint-Laurent
Range of occurrence in Canada: Lake Erie, Lake St. Clair, lower Lake Huron

Demographic Information

Generation time	2 yrs
Is there an observed, inferred, or projected continuing decline in number of mature individuals?	Yes
Estimated percent of continuing decline in total number of mature individuals within 5 years or 2 generations	+26% (Interagency trawl) -95% (Partnership gillnet) -99% (OH trawl)
Observed, estimated, inferred, or suspected percent reduction or increase in total number of mature individuals over the last 10 years, or 3 generations.	-71% (Interagency trawl) -97% (Partnership gillnet) -99% (OH trawl)
Projected or suspected percent reduction or increase in total number of mature individuals over the next 10 years, or 3 generations.	Unknown
Observed, estimated, inferred, or suspected percent reduction or increase in total number of mature individuals over any 10 years, or 3 generations period, over a time period including both the past and the future.	-71% (Interagency trawl) -97% (Partnership gillnet) -99% (OH trawl)
Are the causes of the decline clearly reversible and understood and ceased?	No
Are there extreme fluctuations in number of mature individuals?	Yes (see Figure 9)

Extent and Occupancy Information

Estimated extent of occurrence (2001-2010 records) 21,354 km² (all records)	7,639 km²
Index of area of occupancy (IAO) 2x2 grid value 300 km² (296 km², if only include Canadian portion of grids; 2001-2010 records) 836 km² (824 km², if only include Canadian portion of grids; all records)	296 km²
Is the total population severely fragmented?	No
Number of locations* Lake Erie, Lake St. Clair, Lake Huron	3
Is there an observed, inferred, or projected continuing decline in extent of occurrence?	Yes
Is there an observed, inferred, or projected continuing decline in index of area of occupancy?	Yes
Is there an observed, inferred, or projected continuing decline in number of populations?	Yes
Is there an observed, inferred, or projected continuing decline in number of locations*?	Yes
Is there an observed, inferred, or projected continuing decline in area, extent and/or quality of habitat?	No

* See definition of location.

Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Lake Erie, Western Basin, See section (Population Sizes and Trends, Abundance)	1,235,137 (2010 estimate)
Lake Erie, Central Basin	Unknown
Lake Erie, Eastern Basin	Unknown
Lake St. Clair	Unknown
Lake Huron	Unknown
Total	>1,235,137

Quantitative Analysis

Probability of extinction in the wild is at least 20% within 20 years or 5 generations, or 10% within 100 years.	Not Applicable

Threats (actual or imminent, to populations or habitats)

Actual
- Habitat Degradation
- Nutrient Loading
- Sediment Loading
- Exotic Species
- Altered Coastal Processes
- Climate Change

Rescue Effect (immigration from American waters of Lake Erie)

Status of outside population? NY (END); OH (Unranked); PA (Candidate)	
Is immigration known or possible?	Possible from adjacent US populations. Impossible from DU2
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

* See definition of location.

Current Status

COSEWIC: none (status designation in 2001 based on 1 DU)

Recommended Status and Reasons for Designation

Recommended Status:	**Alpha-numeric code:**
Endangered	A2bce; B2ab(v)
Reasons for designation: This small-bodied fish is native to the middle Great Lakes and has a small distribution range in Canada. Its abundance has declined substantially over the past ten years. Moreover, the longest consecutive time series of lowest abundance has been observed over the last five years. The species is assessed at high risk of extirpation from several threats including habitat degradation, competition with invasive exotic species, and climate change. This species is considered at risk in several border states, including Michigan and New York.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets A2bce for Endangered with an observed reduction in an index of abundance, a decline in the index of area of occupancy, extent of occurrence and quality of habitat, and threats from introduced taxa and pollutants.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered under B2ab(v) with a small index of area of occupancy, few locations and inferred decline in the number of mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. No information on the number of mature individuals.
Criterion D (Very Small or Restricted Total Population): Not applicable. No information on the number of mature individuals.
Criterion E (Quantitative Analysis): Not applicable. Quantitative analysis not completed.

TECHNICAL SUMMARY – DU2

Macrhybopsis storeriana
Silver Chub — Méné à grandes écailles
Saskatchewan-Nelson River population — Population des rivières Saskatchewan et Nelson
Range of occurrence in Canada:Manitoba, Assiniboine and Red rivers and Lake Winnipeg watersheds

Demographic Information

Generation time	2 yrs
Is there an observed, inferred, or projected continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within 5 years or 2 generations	Unknown
Observed, estimated, inferred, or suspected percent reduction or increase in total number of mature individuals over the last 10 years, or 3 generations.	Unknown
Projected or suspected percent reduction or increase in total number of mature individuals over the next 10 years, or 3 generations.	Unknown
Observed, estimated, inferred, or suspected percent reduction or increase in total number of mature individuals over any 10 years, or 3 generations period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence	56,619 km²
Index of area of occupancy (IAO) 2x2 grid value	6,084 km²
Is the total population severely fragmented?	No
Number of locations*	3
Is there an observed, inferred, or projected continuing decline in extent of occurrence?	No
Is there an observed, inferred, or projected continuing decline in index of area of occupancy?	No
Is there an observed, inferred, or projected continuing decline in number of populations?	No
Is there an observed, inferred, or projected continuing decline in number of locations*?	No
Is there an observed, inferred, or projected continuing decline in area, extent and/or quality of habitat?	No
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

* See definition of location.

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Assiniboine River above the Portage Diversion Dam	Unknown
Assiniboine River below the Portage Diversion Dam and Red River from the U.S. border to the St. Andrews Lock and Dam	Unknown
Red River below the St. Andrews Lock and Dam and Lake Winnipeg	Unknown
Total	

Quantitative Analysis

Probability of extinction in the wild is at least 20% within 20 years or 5 generations, or 10% within 100 years.	Not Applicable

Threats (actual or imminent, to populations or habitats)

Potential threats include habitat degradation and climate change, which in other parts of the species' range have resulted in threatened or endangered status. There is no evidence of substantial negative impacts of these threats in this DU, at this time.

Rescue Effect (immigration from Minnesota or North Dakota)

Status of outside population?	Unranked
Is immigration known or possible?	Possible for Red, lower Assiniboine rivers, and Lake Winnipeg. Impossible from DU1.
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Yes, for Red, lower Assiniboine rivers, and Lake Winnipeg

Current Status

COSEWIC: none (status designation in 2001 based on 1 DU)

Recommended Status and Reasons for Designation

Recommended Status:	**Alpha-numeric code:**
Not at risk	NA

Reasons for designation:
This small-bodied fish inhabits rivers and lakes in the Saskatchewan-Nelson watershed. There is no evidence of decline in abundance or range, and recent sampling suggests that this is a widespread species, but one which is not particularly abundant anywhere in the watershed.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No information on the number of mature individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Broad distribution and no evidence of decline or fluctuation.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. No information on the number of mature individuals.
Criterion D (Very Small or Restricted Total Population): Not applicable. No information on the number of mature individuals.
Criterion E: (Quantitative Analysis): Not applicable. Quantitative analysis not completed.

PREFACE

Nothing new has been published on the biology of Silver Chub since the last COSEWIC report. However, it has been listed under the federal *Species at Risk Act* and a management plan has been published for it. All sites where it had been found in southwestern Ontario have been sampled since the last report. In Ontario, it has been captured at fewer sites, and is present at only two of five locations identified in the previous report; as a result of absence at three historical locations, extent of occurrence and area of occupancy have declined by 64%. In Manitoba, the species is still present at all three locations identified in the previous report and has expanded its range in the Assiniboine River likely as a result of sampling effort and gear. There has been insufficient sampling to determine trends in abundance in Manitoba. Although threats specific to Silver Chub are unknown, they are believed to be impacted by degradation of habitat and water quality, and exotic species—all ongoing threats within their distribution in Canada but likely most severe within the Great Lakes-Upper St. Lawrence DU.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2012)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Silver Chub

Macrhybopsis storeriana

Great Lakes - Upper St. Lawrence populations
Saskatchewan - Nelson River populations

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2012

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Class	Actinopterygii
Order	Cypriniformes
Family	Cyprinidae
Species	*Rutilus storerianus*, Kirtland 1842: 71 *Leuciscus storerianus*, Kirtland 1845: 199 *Gobio vernalis*, Girard 1856: 189 *Ceratichthys lucens*, Jordan 1880: 238 *Hybopsis storerianus*, Jordan and Evermann 1896–1900: 321 *Hybopsis storeriana*, Speirs 1951: 18 *Macrhybopsis storeriana*, Gilbert 1998: 152

The Silver Chub, *Macrhybopsis storeriana* (Kirtland 1845) (Figure 1) is one of four species of the genus *Macrhybopsis* in the family Cyprinidae (Nelson *et al.* 2004), and the only species of the genus *Macrhybopsis* in Canada (Scott and Crossman 1998). Although this species first appeared in Kirtland (1842) as "The true *Rutilus plagurus*", it is currently valid as *Macrhybopsis storeriana* (Kirtland 1845 as cited in Eschmeyer 2010). Although the description date for the species is often cited as either 1844 or 1847, Eschmeyer (2010) considers 1845 to be the valid date; Kirtland 1844 has a signature date of November 1844, but was probably published in 1845.

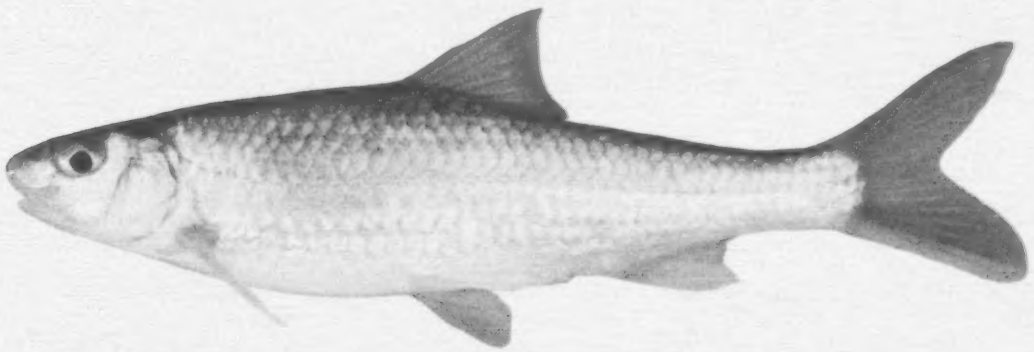

Figure 1. Silver Chub, *Macrhybopsis storeriana*, collected from the Assiniboine River, Manitoba. D.A. Watkinson photo.

The Silver Chub was removed from the genus *Hybopsis* and placed in the resurrected genus *Macrhybopsis* by Mayden (1989) and Coburn and Cavender (1992). This was adopted in the 1991 American Fisheries Society checklist (Robins *et al.* 1991).

The Silver Chub is also commonly known as Storer's Chub and the French common name is *méné à grandes écailles* (Scott and Crossman 1973).

Morphological Description

Species in the genus *Macrhybopsis* are characterized by the presence of a slender barbel at the end of the maxillary, moderate-sized subterminal mouth, snout projecting beyond mouth, and fewer than 50 lateral line scales (Scott and Crossman 1973; Page and Burr 2011; Stewart and Watkinson 2004; Holm *et al.* 2010). In a phylogenetic analysis, Coburn and Cavender (1992) indicated that the genus *Macrhybopsis* formed a monophyletic group based on six osteological characters.

The Silver Chub differs from other species in the genus in having a larger eye on the upper half of the head, a shorter snout, silvery sides lacking a band or markings and the origin of the dorsal fin placed anterior to the origin of the pelvic fin (Page and Burr 2011; Pflieger 1975; Werner 2004). It reaches a maximum length of 231 mm total length (TL) (Trautman 1981; Page and Burr 2011).

Silver Chub can be confused with the large Spottail Shiner, *Notropis hudsonius* (Kinney 1954). It also resembles the extirpated Gravel Chub, *Erimystax x-punctatus* and species in the genus *Nocomis*. It can be distinguished from the Spottail Shiner by the presence of a terminal barbel. In comparison to the Gravel Chub, the Silver Chub lacks distinct, dark, x-shaped spots on the body (Holm *et al.* 2010). The snout projects further beyond the mouth in the Silver Chub than in the *Nocomis* species, and the *Nocomis* species have smaller eyes and a more pigmented body that is not usually silvery (Scott and Crossman 1973; Trautman 1981; Page and Burr 2011).

Population Spatial Structure and Variability

Population and genetic studies have not been conducted on Silver Chub; therefore, little is known on the population structure and genetic variability of the species.

Designatable Units

Based on the COSEWIC National Freshwater Biogeographic Zone classification (www.cosewic.gc.ca), the Great Lakes populations are found within the Great Lakes-Upper St. Lawrence Biogeographic Zone, and the Manitoba populations are found in the Saskatchewan-Nelson River Biogeographic Zone. The population structure within each of these zones is unknown. Therefore, there are two DUs based on the occurrence of discrete populations in two separate Biogeographic Zones. These isolated populations may be distinct genetically or morphologically; however, genetic or morphological variation has not been analyzed.

Special Significance

The Silver Chub is the only member of its genus in Canada. The Great Lakes and Lake Winnipeg populations are lacustrine. The Great Lakes populations differ morphologically, and may be genetically distinct from the riverine forms found throughout most of its range in the United States. These two populations are also isolated from most other Silver Chub populations, which occur in the Mississippi River drainage. The species is common at times in the western basin of Lake Erie and in the main branch of the Assiniboine and Red rivers and, therefore, would contribute to the forage base for sport and commercial fish species. The species is considered common in North America (Page and Burr 2011).

The importance of Silver Chub to First Nations people is unknown. At the time of submission, no Aboriginal Traditional Knowledge (ATK) was available for inclusion in this report.

DISTRIBUTION

Global Range

The distribution of the Silver Chub extends from Lake Winnipeg and the southern Great Lakes basin south to the mouth of the Mississippi River (Gilbert 1980; Werner 2004) (Figure 2). In the Great Lakes basin, the Silver Chub is limited to Lake Erie, Lake St. Clair, and the extreme southern portion of Lake Huron. In the Lake Winnipeg drainage, it is found in southern Lake Winnipeg and in the Assiniboine and Red River drainages of Manitoba, North Dakota, and Minnesota. It occurs in the Mississippi River system from Minnesota south to the Gulf of Mexico. In the northern part of its range in the Mississippi basin, it extends from Nebraska to New York (where it was last taken in 1928 (Werner 2004)); and, in its Gulf Coast range, it extends from the Mobile Bay basin to the Lake Pontchartrain drainage. There is also an isolated population in the Brazos River drainage of Texas. The Silver Chub has not been seen in the Kansas River since 1980 (Miller and Gress 2010) and it is a species of concern in the Missouri National Recreational River in Nebraska and South Dakota (Berry and Young 2004).

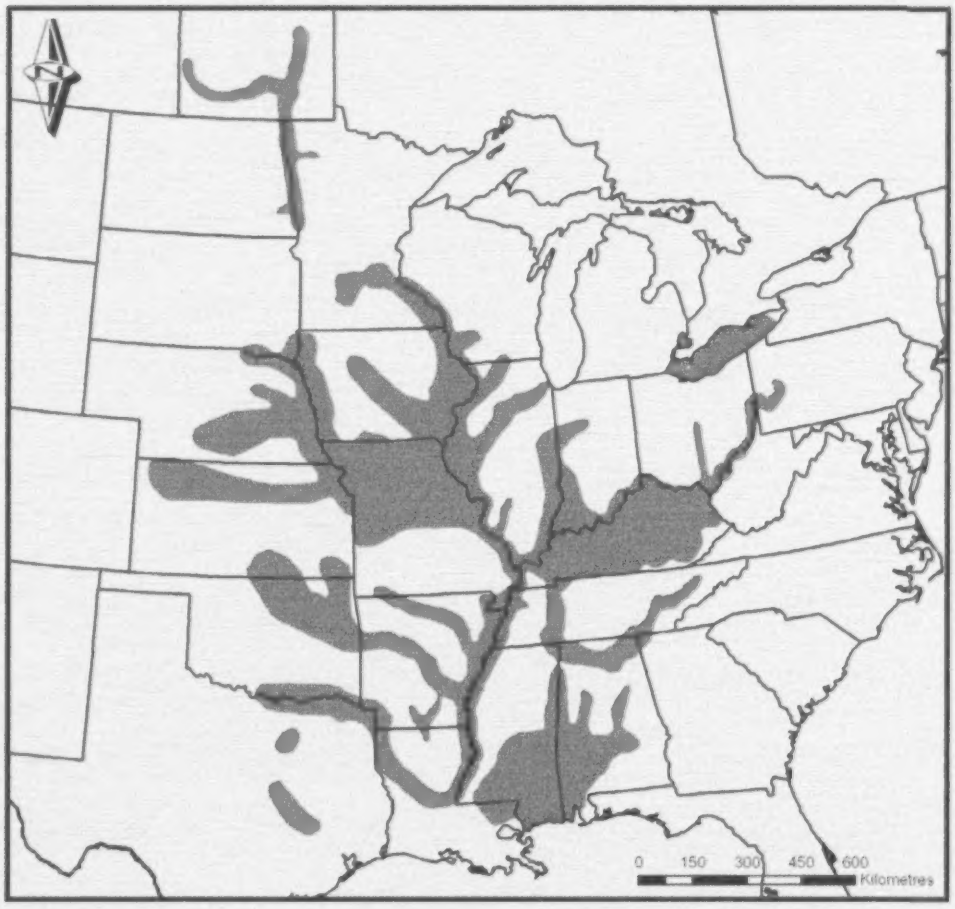

Figure 2. Global distribution of the Silver Chub (modified from Boyko and Staton 2010).

Canadian Range

In Ontario, Silver Chub was collected before 1980 along most of the north shore of Lake Erie and the south and east shores of Lake St. Clair (Figure 3). Most of the records for Lake Erie were collected prior to 1960 and since 1990, whereas the Lake St. Clair records were collected in the 1970s and 1980s. Since 1980, the Silver Chub has been collected primarily in the western and central basins of Lake Erie, with a few occurrences in Lake St. Clair, and a single occurrence in Lake Huron. The increase in records from the western basin of Lake Erie in the 1990s is likely a reflection of the species' recovery since the 1980s. However, the spatial extent of records has decreased in the last 10 years based on ongoing standardized sampling, which has led to a consequent 64% decline in both extent of occurrence (EO) and the index of area of occupancy (IAO). The current distribution of the species in Lake Erie likely represents a single location.

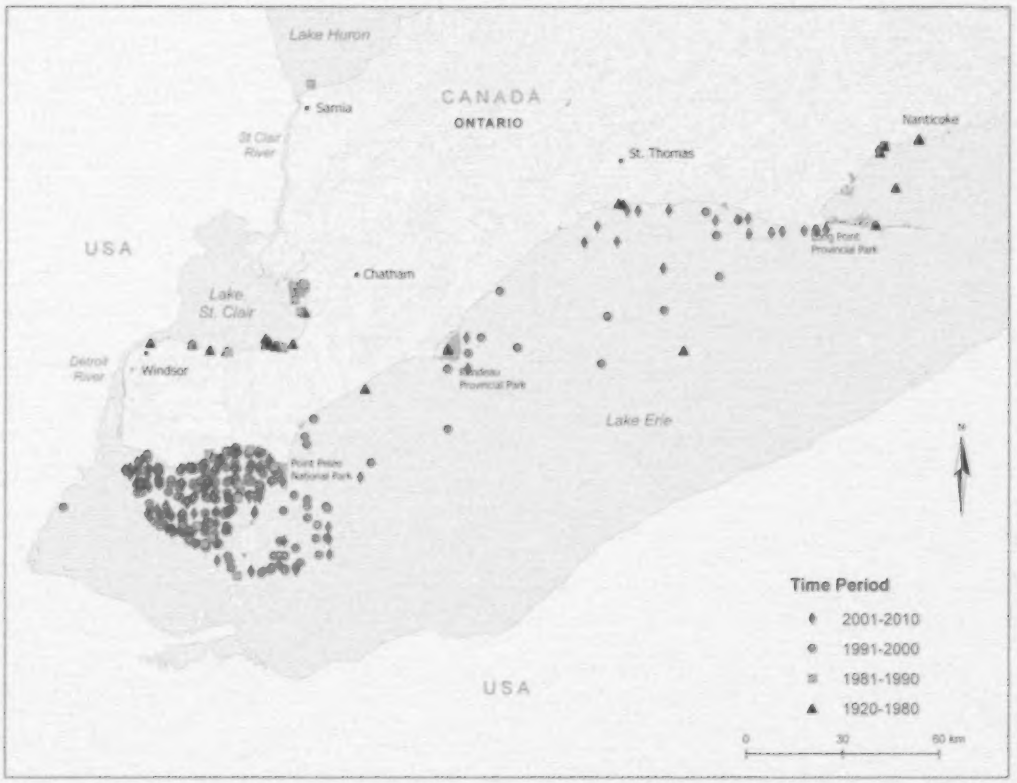

Figure 3. The distribution of Silver Chub in Ontario.

In Manitoba, collections of Silver Chub before 1980 defined the extent of its range in the Red River from the mouth of the Morris River north to downstream of St. Andrews Lock and Dam and the Assiniboine and La Salle rivers near their confluences with the Red River (Figure 4). Sampling conducted in the 1980s, and 1990s, expanded its range to include the Red River near the United States border north to Lake Winnipeg, and the south basin of Lake Winnipeg, as well as the Assiniboine River from downstream of Spruce Woods Provincial Park to its confluence with the Red River (D. Watkinson, unpublished data). Sampling conducted in the 2000s expanded the species' distribution to include the upper reaches of the Assiniboine River in Manitoba (Figure 4) (D. Watkinson, unpublished data). Increases in sampling effort and improvements in gear used in the last 10 years have expanded the EO and IAO of Silver Chub in Manitoba. The current distribution of the species in Manitoba likely represents three locations, isolated from one another by dams.

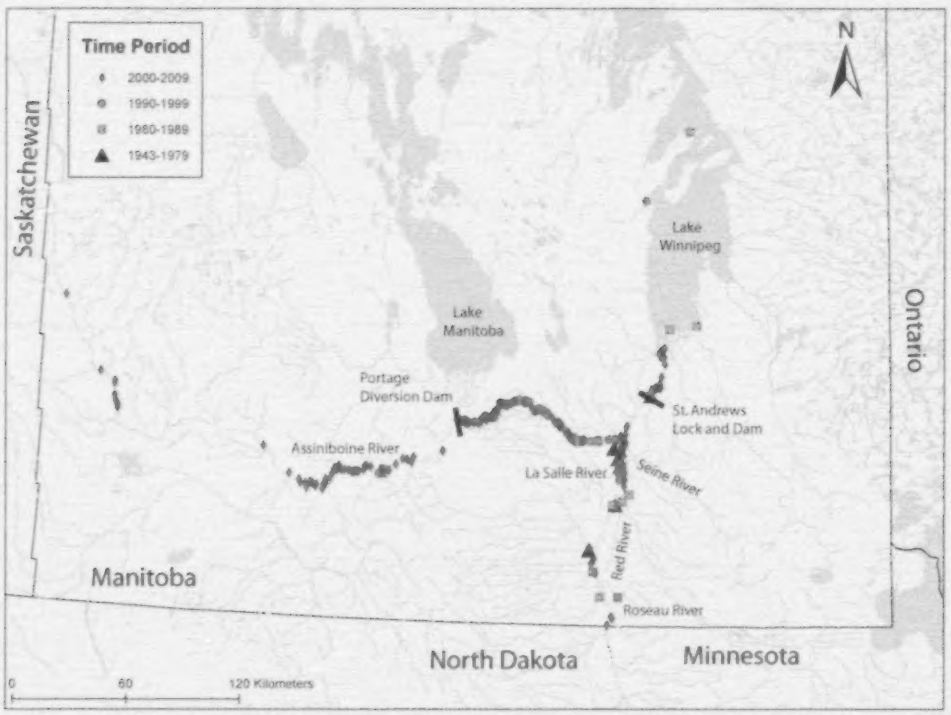

Figure 4. The distribution of Silver Chub in Manitoba.

Search Effort

It is difficult to draw conclusions regarding the population trends of Silver Chub in Canada as many of the surveys that have detected the species were not specifically targeting Silver Chub, and sampling gears often varied among collections. Table 1 outlines known surveys within the range of Silver Chub in Canada. Future targeted surveys, using gear types proven efficient at detecting the species and sampling at appropriate times, will provide a more accurate picture of the status of the Silver Chub in Canada.

Table 1. Summary of recent fish surveys since 1974 for DU1 and 1994 for DU2 (when standardized sampling commenced) throughout the range of the Silver Chub in Canada. The species was detected during surveys in bold (modified from Boyko and Staton 2010).

Waterbody/General Area	Survey Description (years of survey effort)
Lake St. Clair	• Nearshore fish community survey, OMNR† (2005, 2007)a • Fish community survey, Michigan DNR (1996–2001)b • Essex-Erie targeted sampling for fishes at risk, DFO (2007)a, c • Fall trap-net survey, OMNR (1974–2007, annual)e • Young-of-the-year index seine survey, OMNR (annual)a • Benthic fish community survey, DFO (2010) b
Detroit River	• Fish-habitat associations of the Detroit River, DFO and University of Windsor (2003–2004)a, d • Coastal wetlands of Detroit River, DFO and University of Guelph (2004–2005) • Fish community surveys, DFO and OMNR (2003, 2004)d • Benthic fish community survey, DFO (2009, 2010) b
Lake Erie proper	• Interagency trawling survey in western basin, OMNR (1988–2010, annual)b • Coastal wetlands along Lake Erie (2004–2005)e • Partnership gill net survey, lake-wide, OMNR (1989–20010, annual)i • Nearshore beach seining surveys, OMNR and DFO (2005–2006)a (Reid and Mandrak 2008) • Nearshore seine survey, west and west-central basins, OMNR (2007)a
Point Pelee	• Fish species composition study (Surette 2006), University of Guelph, DFO and PPNP (2002–2003)a, c, f, g, h • Spotted Gar surveys, DFO and University of Windsor (2009) f
Rondeau Bay	• Fish community surveys, OMNR and DFO (2004–2005) a, d, f • Spotted Gar surveys, DFO and University of Windsor (2006-2008) f, d
Long Point Bay	• Index surveys, OMNR (annually)b • Essex-Erie targeted sampling for fishes at risk (Turkey Point), DFO (2007) a, c, d • Spotted Gar surveys, DFO and University of Windsor (2008-2009) f
Assiniboine River	• Instream flow needs long-track fish survey, DFO (1995, 1996, 2001, 2002)d • Silver Chub survey DFO (2009)j
Red River	• Species at risk fish survey, DFO (2002–2003)d • Silver Chub survey (limited effort) DFO (2009)j
Lake Winnipeg – North Basin, South Basin, Channel Area	• Species distribution and abundance, pelagic trawling surveys, Manitoba Water Stewardship, Lake Winnipeg Consortium, and DFO (2002–present, annually)b

† Acronyms: OMNR – Ontario Ministry of Natural Resources; DNR – Department of Natural Resources; DFO – Fisheries and Oceans Canada; and PPNP – Point Pelee National Park
Gear type: a – seine net; b – trawl; c – trap net; d – boat electrofishing; e – backpack electrofishing; and, f – fyke net; g – minnow trap; h – Windemere trap; i – gill net; j – mini-Missouri trawl.

Table 2. Threat classification table for the Silver Chub in DU1 – Great Lakes-Upper St. Lawrence (adapted from EERT 2008).

Specific Threat	Extent (widespread/ localized)	Frequency (seasonal/ continuous)	Causal Certainty (high, medium, low)	Severity (high, medium, low)	Overall Level of Concern (high, medium, low)
Habitat Degradation	Widespread	Continuous	High	High	High
Nutrient Loading	Widespread	Continuous	High	High	High
Sediment Loading	Widespread	Continuous	Medium	High	High
Climate Change	Widespread	Continuous	Medium	High	High
Exotic Species	Widespread	Continuous	Low	Medium	High
Altered Coastal Processes	Widespread	Continuous	Low	Low	Low
Baitfish Harvesting	Localized	Seasonal	Low	Low	Low

DU1 – Great Lakes-Upper St. Lawrence Biogeographic Zone

Historically, Silver Chub were captured in Ontario Ministry of Natural Resources (OMNR) trawling and gillnetting programs in lakes Erie and St. Clair. More recently, Silver Chub have been collected in three annual standardized netting programs in Lake Erie: OMNR Lake Erie Partnership Gill Net Index Program with data extending back to 1989; OMNR bottom trawl program with standardized data extending back to 1988 for the western basin; and Ohio Department of Natural Resources adult and young-of-year (YOY) bottom trawl program with standardized data extending back to 1990 for the central and western basins. The Michigan Department of Natural Resources conducted annual bottom trawl surveys in Lake St. Clair (including the Canadian side) between 1996 and 2001 and did not catch any Silver Chub (Thomas and Haas 2004), despite using mesh sizes effective at detecting Silver Chub. Several recent surveys of Lake St. Clair and Detroit River failed to collect any Silver Chub.

DU2 – Saskatchewan-Nelson River Biogeographic Zone

Our knowledge of the distribution of Silver Chub in Manitoba prior to 1995 is largely based on a fish distribution database maintained by Ken Stewart at the University of Manitoba. This database contains the results of the extensive, long-term sampling of fishes in southern Manitoba and documents collections made in the Assiniboine, Red, Seine, La Salle, Morris, and Roseau rivers and Lake Winnipeg (Figures 4 and 5). Sampling gear used to collect Silver Chub included seine nets and small mesh gill nets (K. Stewart, pers. comm. 2010). From 1943 to 1994, 774 Silver Chub were sampled in 46 collections on the Red River or its tributaries, 102 Silver Chub were sampled in 25 collections in the Assiniboine River, and four Silver Chub were sampled in three collections on Lake Winnipeg or its tributaries. One site on the Red River near the Red River Floodway Control Structure was sampled in 12 years between 1976 and 1994. The number of Silver Chub in collections generally increased during this period; however, there is no record of effort to quantify this trend.

Since 1994, Fisheries and Oceans Canada (DFO) has maintained a database that documents 4,180 collections made by DFO in the Assiniboine, Red, Seine, La Salle, Morris, and Roseau rivers, and Lake Winnipeg (Figure 4). Most of this effort is non-directed boat electrofishing surveys conducted in the Assiniboine and Red rivers between 1995 and 2005 (Figure 4). Boat electrofishing surveys of the Assiniboine River conducted in 1995 and 1996 collected 46 Silver Chub in 2,250 minutes of effort (0.01824 fish/min). Boat electrofishing surveys of the Assiniboine River from 2001 to 2003 collected 34 Silver Chub in 2,350 minutes of effort (0.01446 fish/min). 2001 to 2005 boat electrofishing surveys in the Red River collected 81 Silver Chub in 4,016 minutes of effort (0.02016 fish/min). In 2009, 313 minutes of boat electroshocking collected no Silver Chub in the La Salle, Seine, or Assiniboine rivers.

In 2009, from June 22 to July 23, DFO conducted a directed bottom trawl survey in the Assiniboine River with additional sampling in the Red River and Morris River near its confluence with the Red River. A mini-Missouri trawl (Herzog *et al.* 2009) designed to specifically sample small-bodied benthic fish was used as well as a larger mesh Missouri trawl (Herzog *et al.* 2005) for a smaller number of trawls. Eighty-one trawls in the Red and Morris rivers collected 10 Silver Chub (0.12 fish/trawl). Sixteen Silver Chub were seined on October 23 in the La Salle River.

In the Assiniboine River, Silver Chub has historically been collected in low numbers at a limited number of sample locations. This was likely an artifact of sampling gear and effort. In the 2000s, its range was extended more than 500 river kilometres upstream (Figure 5) (Watkinson, unpublished data). In 2009, Missouri and mini-Missouri trawl collections made between river kilometres 0 and 154 sampled 85 Silver Chub in 133 trawls (0.64 fish/trawl), between river kilometres 281 and 294, 116 Silver Chub were sampled in 114 trawls (1.02 fish/trawl), and between river kilometres 605 and 677, 10 Silver Chub were sampled in 143 trawls (0.07 fish/trawl).

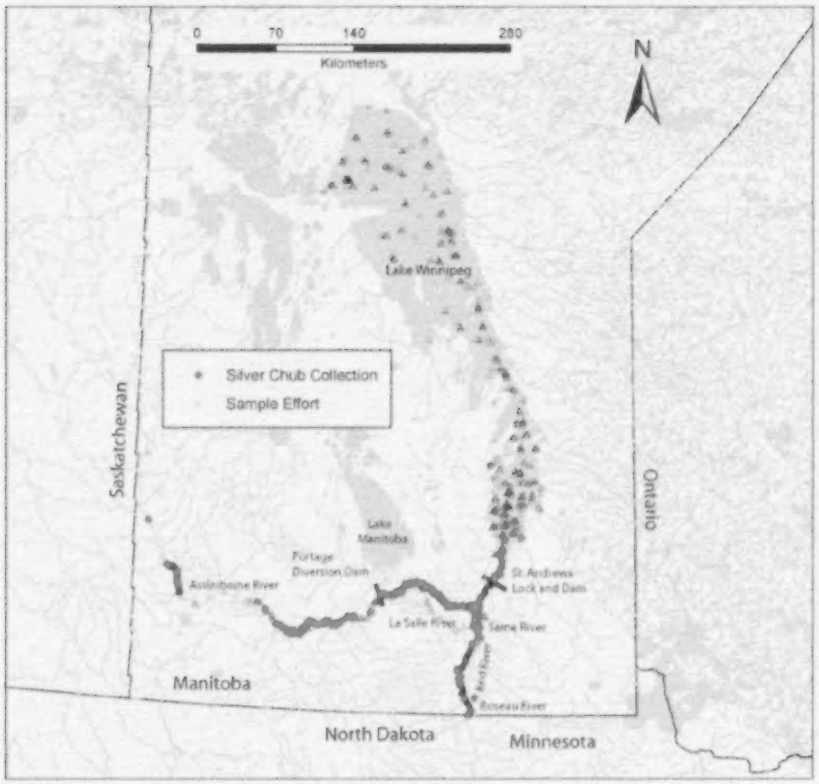

Figure 5. Sampling locations in Red, Assiniboine, Roseau, Seine, and La Salle rivers and Lake Winnipeg, with Silver Chub collections indicated.

Silver Chub were collected in the Lake Winnipeg drainage only three times since 1984, despite sampling of known localities dating back to 1954. Annual pelagic trawling surveys of Lake Winnipeg, conducted since 2002 by Manitoba Water Stewardship, the Lake Winnipeg Consortium, and DFO, have not detected Silver Chub in 1,191 trawls. This sampling is restricted to the pelagic portion of the water column in offshore areas with greater than 4.5 m water depth. Given the large number of fishes sampled, it is possible that Silver Chub was confused with more common species. Most likely, Silver Chub abundance in Lake Winnipeg is low and pelagic trawling did not sample benthic habitat where Silver Chub may be more abundant.

HABITAT

Habitat Requirements

In Ontario, the species is found in large lakes but may also occur in connecting rivers (i.e., St. Clair and Detroit rivers). In 1995, it was captured at depths of 7.6–12 m (Schwier *et al.* 1995a, 1995b) in Lake Erie but it has been reported from as deep as 20 m (Kinney 1954). In the partnership gill net surveys, Silver Chub have been caught between 4 and 24 m (average depth for presence = 10.5 m), primarily in nets fished on bottom. In the western basin interagency bottom trawls, Silver Chub were caught at depths from 2.3 to 13.7m (mean depth for presence = 8.2 m) (Anonymous reviewer, pers. comm., 2011).

In Manitoba, it is found primarily in the mainstem of large turbid rivers with moderate (not turbulent) flow. Silver Chub have been collected in 0.3–4.2 m of water (mean 1.2 m) and water velocities of 0.01–1.0 m/s (mean 0.5 m/s) (Watkinson, unpublished data). Silver Chub are predominately collected over sand substrate (Watkinson, unpublished data). It is usually not associated with aquatic vegetation (K. Stewart, pers. comm. 2010).

In Ohio, it reached greatest abundance over substrates of clean gravel and sand and appeared to be rather susceptible to pollutants of diverse types (Trautman 1981). Kinney (1954) reported that it was more commonly found over silt bottoms in Lake Erie backwater habitat (Robison and Buchanan 1992). In the United States bordering Lake Erie, the Silver Chub is found in mouths of streams with fine gravel or sand bottoms (Werner 2004). In Missouri, Pflieger (1975) reported the Silver Chub from "quiet pools and backwaters of large streams" and in large reservoirs and natural lakes. In Arkansas, it was most abundant in deep water of moderate to swift current in the large rivers and collected in very small numbers in backwater habitat. In the Arkansas River, it was found over sand substrate in the daytime but moved to shore (0.5–1 m water depth) at night to feed. The species was "quite tolerant of silty turbid streams" and was also common in some reservoirs in Oklahoma (Robison and Buchanan 1992). Piller *et al.* (2004) found Silver Chub abundance significantly increased in the Pearl River following human-caused disturbances that increased the proportion of mobile substrate in the system. It is known to overwinter in deep holes in the Mississippi River (NatureServe 2010). Sheaffer and Nickum (1986) found larval and juvenile Silver Chub in equal numbers in surface and bottom sampling and their abundance was higher in backwaters than the main channel of the upper Mississippi River.

Habitat Trends

The decline in numbers of Silver Chub in Lake Erie in the 1960s was likely related to habitat degradation, eutrophication, and sediment and nutrient loadings, resulting in reduced oxygen levels and a consequent decline in its preferred prey, mayflies in the genus *Hexagenia* (Scott and Crossman 1973). Although the Silver Chub has been recorded from turbid rivers, Trautman (1981) noted that it moved into clearer water and gravelly substrates when pools became excessively silted. Significant increases in total nitrogen and phosphorus in the Assiniboine and Red river drainages in the past 30 years (Jones and Armstrong 2001) have increased eutrophication of Lake Winnipeg.

BIOLOGY

Life Cycle and Reproduction

The reproduction of Silver Chub is still poorly known. Most individuals mature as early as age 1 and reach a maximum age of 3, rarely 4 (Kinney 1954), with a generation time of 2 yrs. A collection of 110 Silver Chub caught in the western basin of Lake Erie in 2000 were aged using scales. The specimens ranged in age from 1 to 4 years, and the mean growth rate was similar to that reported by Kinney (1954), prior to their disappearance from Lake Erie in the early 1960s (Figure 6; Mandrak, unpublished data). Silver Chub from Manitoba have not been aged but the length frequency plot of 221 fish collected in 2009 from June 22 to July 22 appears to have three modes indicating that fish live to at least three years old (Figure 7). Scott and Crossman (1973) and NatureServe (2010) stated that it probably spawns in open water; however, Kinney (1954) observed that the species moved nearshore presumably to spawn in Lake Erie. Goodyear *et al.* (1982) suggested that Silver Chub historically spawned over clean gravel substrates in tributaries of Lake Erie. In Ohio, Silver Chub spawns in late May or early June, possibly in open water, when water temperature reaches 21°C (Werner 2004).

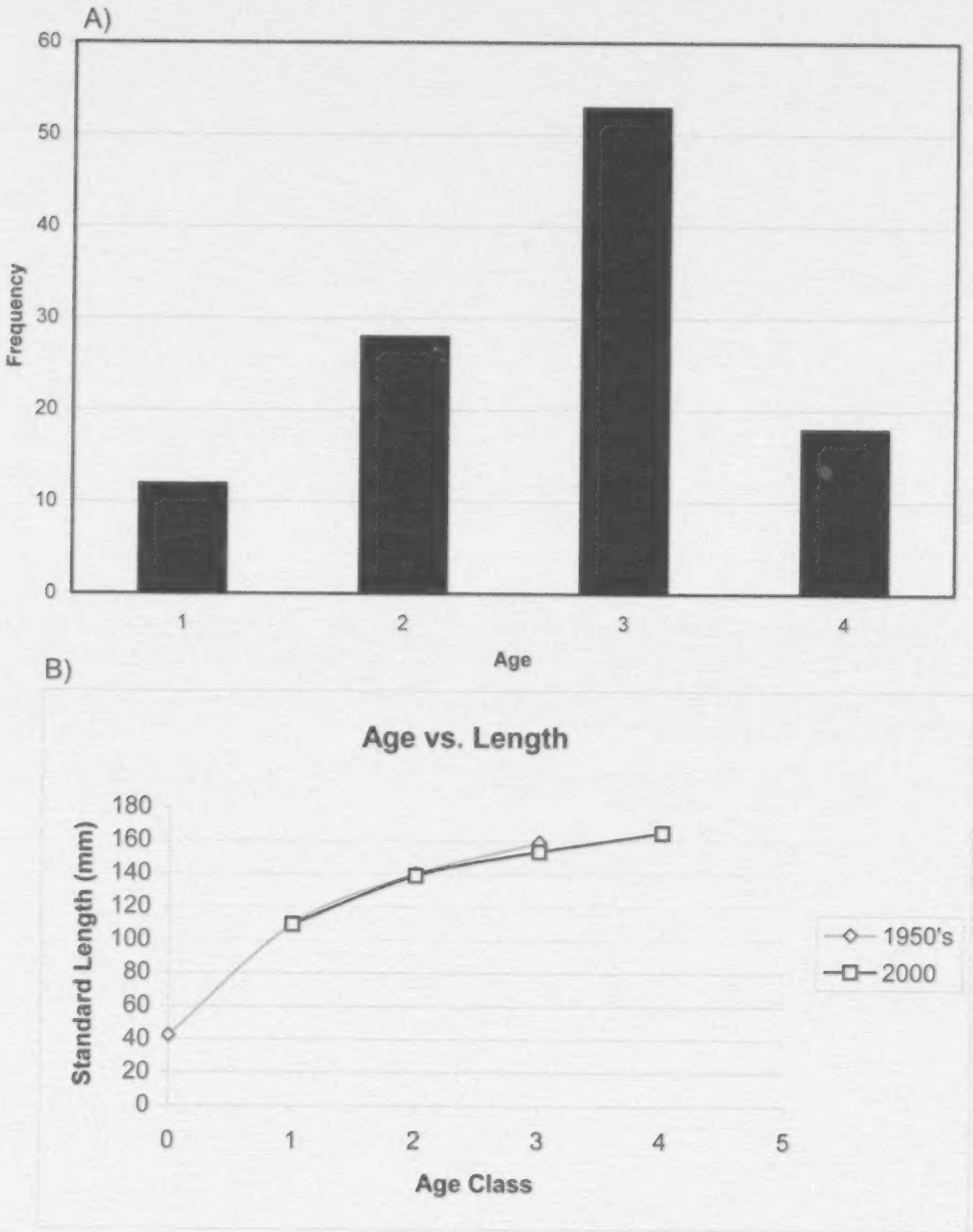

Figure 6. Age (a) and growth (b) of 110 Silver Chub collected in Lake Erie in 2000 and compared to Kinney (1954). (Mandrak, unpublished data).

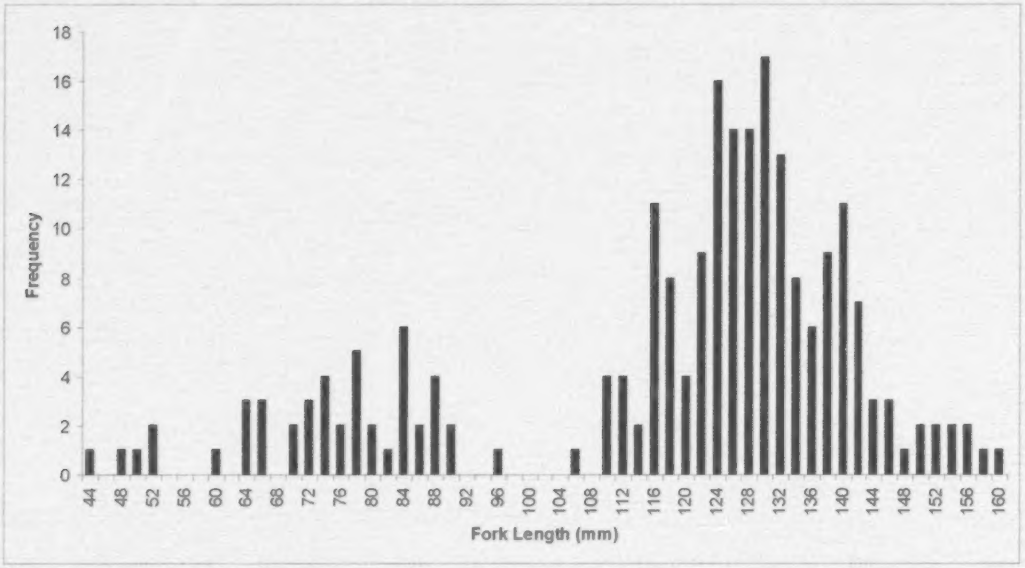

Figure 7. Length-frequency plot of 221 Silver Chub collected June 22 to July 22, 2009 in Manitoba (Watkinson, unpublished data).

In Canada, spawning occurs in spring or early summer (May to July) at temperatures of 19–23°C (Holm *et al.* 2010). Fecundity can be as high as 12,311 eggs (Coad 1995). Ripe males 130 and 134 mm fork length (FL) were collected in the Assiniboine River on July 20 and 21, 2009 over sand substrate, in 1 and 2.3 m of water, at water temperatures of 22.5 and 20.5°C.

Dispersal and Migration

Kinney (1954) noted that Silver Chub leave the open waters of Lake Erie and move into nearshore areas in March and April presumably to spawn in late May or early June. The extent of Silver Chub movement within Lake Erie (e.g. across the International boundary) is unknown. Movement of Silver Chub in Manitoba is unknown.

Feeding

The Silver Chub is a bottom feeder that uses both taste and sight to obtain its food. External taste buds are located on the head and pectoral fins. It feeds on a variety of items depending on age and available food. In the Mississippi and Richmond rivers of Wisconsin, diet consisted of aquatic insect larvae, Hemiptera, Coleoptera, crustaceans, and molluscs (Becker 1983). Historically, in Lake Erie, young fed on small crustaceans (copepods, *Daphnia*, ostracods, and *Gammarus*) and insect larvae (midges, caddisflies, and mayflies). Older individuals in Lake Erie fed primarily on the mayfly nymph, *Hexagenia*, when available (Scott and Crossman 1973). Examination of 12 stomachs from large (188–228 mm TL) female Silver Chub captured in Lake Erie on 9 June 1997 (Royal Ontario Museum Catalogue Number 70921) indicated that the most common

food item was the mayfly nymph *Hexagenia limbata* (present in 8 of 12 stomachs). Other items included fish eggs of approximately 1.0–1.4 mm in diameter (3 of 12); Zebra Mussel, *Dreissena polymorpha,* (2 of 12); *Cypria,* an ostracod (1 of 12); *Oecetis* (a caddisfly) (1 of 12); and possibly a small fish (1 of 12). Etnier and Starnes (1993) noted that the Silver Chub moves into reservoirs in Tennessee where the introduced clam *Corbicula* is abundant. A study of 110 Silver Chub collected in Lake Erie in 2000, found that 86% of the stomachs contained dreissenid mussels, 22% sphaeriids, 15% Coleoptera, 10% *Hexagenia*, and less than 10% contained a variety of other insects (Mandrak, unpublished data). Although these data suggest that Silver Chub preferred feeding on dreissenid mussels rather than the mayfly nymph, the specimens used were collected from June to November, while those collected by Kinney (1954) between February and May, had a high percentage of *Hexagenia* spp. in their guts. Therefore, post-dreissenid invasion, Silver Chub may switch prey items, depending on seasonal availability, and mayfly nymphs may be more predominant in their diet in early spring, when nymphs emerge and swim to the surface (Boyko and Staton 2010).

POPULATION SIZES AND TRENDS

DU1 – Great Lakes-Upper St. Lawrence Biogeographic Zone

Sampling Effort and Methods

A summary of sampling efforts and methods since 1974 (when standardized sampling commenced) is included in Table 1, modified from Boyko and Staton (2010).

Abundance

There is limited information available concerning the size of Silver Chub populations in Canada. Only the standardized Interagency Trawl Index Data (OMNR, ODNR), initiated in the western basin of Lake Erie in 1988, has estimated absolute abundance. Absolute abundance is calculated by determining the density of Silver Chub in the trawl area, multiplying it by the total area of the depth strata, and summing the results for all of the depth strata. Estimates of absolute abundance exhibit a steady rise from 1,336,105 in 1988 to 5,108,558 in 1994, increased to 39,789,297 in 1996 and 46,880,541 in 1999, and then declined to less than 2,600,000 individuals since 2005 (Figure 8).

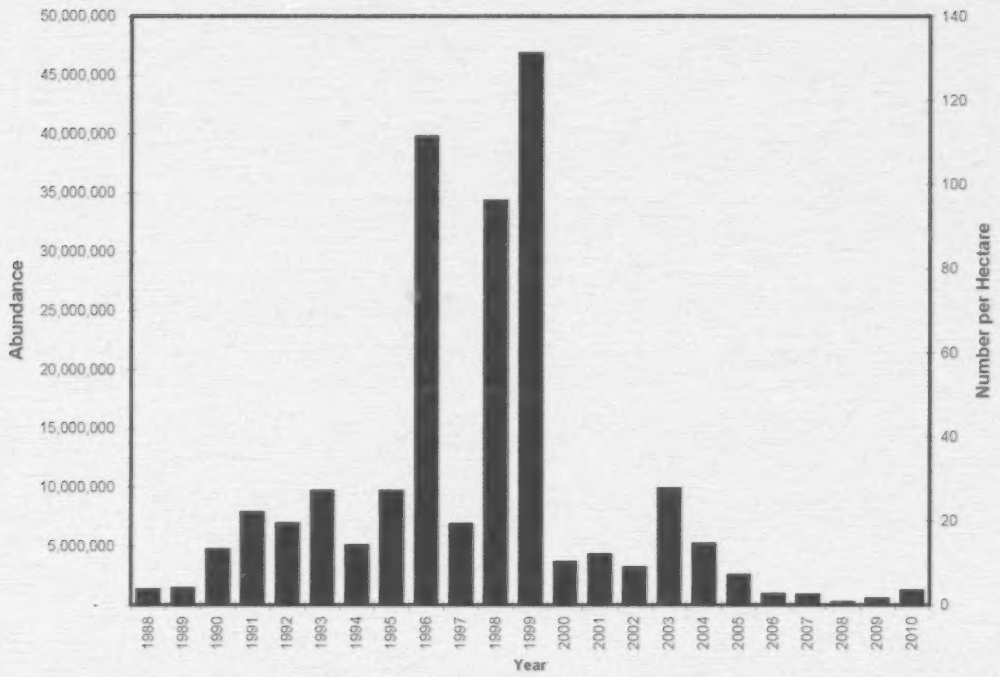

Figure 8. Silver Chub collections in the Interagency Trawling Program in the western basin of Lake Erie, 1988–2010.

Fluctuations and Trends

In Lake Erie, a dramatic decline in the Silver Chub began in the late 1940s. As of 1973, the last known record of Silver Chub was recorded in 1960 (Canadian Museum of Nature Catalogue Number NMC60-0476A) leading Scott and Crossman (1973) to state, "the present status of the species in Lake Erie is in doubt but obviously it is rare". However, Scott and Crossman (1973) were apparently not aware that Silver Chub began appearing in Ontario Ministry of Natural Resources (OMNR) midwater trawls and bottom gillnets in 1967 (S. Nepszy, pers. comm. 2000, cited in Mandrak and Holm 2001).

The standardized Interagency Trawl Index Data (OMNR, ODNR) exhibit a steady rise from 3.6 individuals per hectare in 1988 to 25.9 individuals per hectare in 1994 (Figure 8). Numbers increased dramatically to 106 individuals per hectare in 1996 and 125 individuals per hectare in 1999, and then declined precipitously to less than 7 individuals per hectare since 2005. There has been a decline of 71% over the last 10 years.

A similar pattern, but with lower mean values, for yearling and older fish was exhibited by additional trawling in the Ohio waters of the western basin in August and fall each year between 1990 and 2010 (Figure 9). Trawling in the Ohio waters confirmed very low numbers in the west-central basin (OH District 2) and virtually no individuals in the east-central basin (OH District 3) (Figure 9). The mean trend across basins is 99% decline over the last 5 and 10 years. YOY data for the same trawls indicated large catches in 1996, 1998, and 1999, but virtually no catches since then.

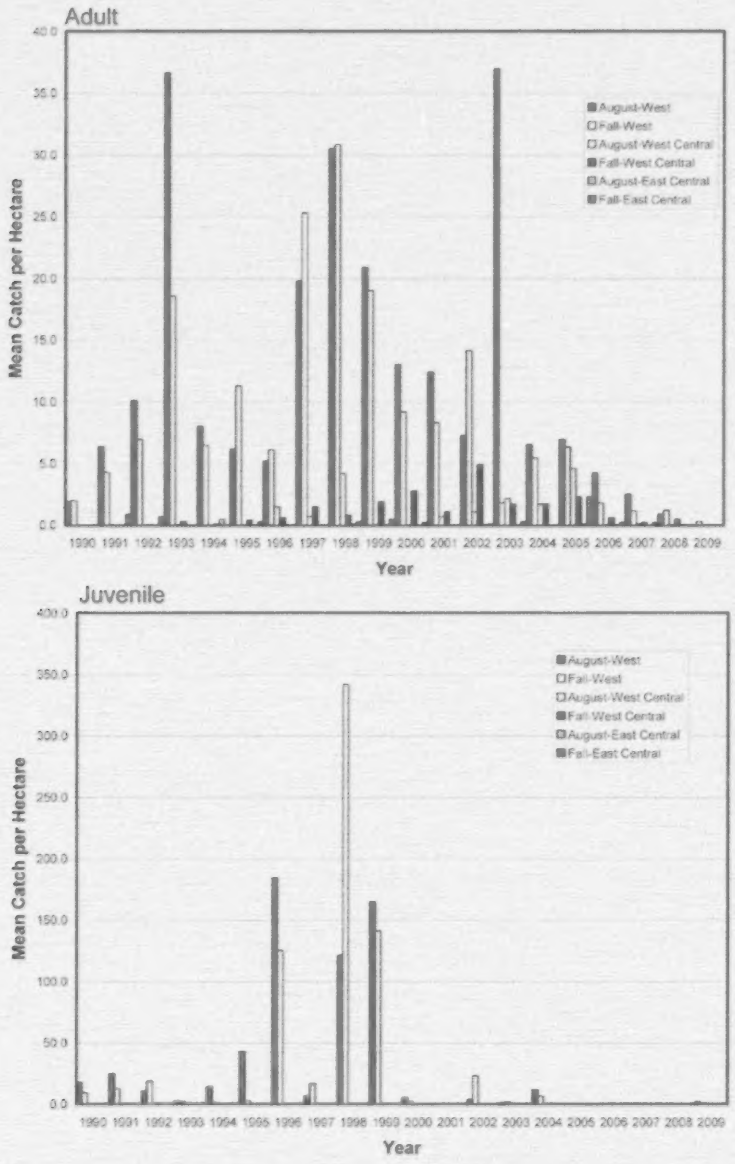

Figure 9. Silver Chub captures in the Ohio DNR trawling program in Lake Erie, 1990–2009.

Data from the Partnership Index Gill Net Index Program (OMNR and commercial fishing agencies) are available for Canadian populations in the western, central, and eastern basins of Lake Erie, 1994 to 2010 (Table 3). In the western basin, the mean catch per gear rises from 2.6 in 1994 to 8.4 in 1999, then drops to 3.8 by 2004, below 2.0 by 2006, and remains below 0.1 by 2008. There were minimal catches in the central basin and only a single fish caught in the eastern basin. The average trend across all basins was a 95% decline over the last 5 years and a 97% decline over the last 10 years.

Table 3. Annual total catch of Silver Chub by gear and location in Ontario Lake Erie Partnership Gill Net Index. Shaded areas indicate years when gear types or surveys were not fished.

Year	West			West-Central			East-Central			East			Pennsylvania Ridge		
	Standard bottom	Standard canned	Aux central 1fa	Standard bottom	Standard canned	Aux central 1fa	Standard bottom	Standard canned	1 m above therm	Standard bottom	Standard canned	Thermocline can	1 m above therm	Standard bottom	Standard canned	Thermocline can
1989							0	0		0	0	0		0	0	
1990	23	0		2	0		0	0		0	0	0		0	0	0
1991	30	0		5	0		0	0		0	0			0	0	
1992	134	0		15	0		1	0		0	0			0	0	
1993	305	0		0	0		0	0		0	0			0	0	
1994	57	2		0	0		0	0		0	0			0	0	
1995	96	0		1	0		0	0		0	0			0	0	
1996	85	4		0	0											
1997	73	0		0	0		0	0								
1998	66	1		2	0		21	0		0	0			0	0	
1999	185	0		4	0		14	0	0	0	0	0	0	0	0	0
2000	132	1		3	0		18	0		0	0	0		0	0	0
2001	61	0		0	0		6	1		1	0	0		3	0	0
2002	48	0		2	0		2	0		0	0	0		0	0	0
2003	44	0		0	0		0	0		0	0	0		8	0	0
2004	84	0	0	0	0	0	1	0		0	0	0		0	0	0
2005	21	0	0	1	0	0	4	0		0	0	0		0	0	0
2006	38	0	0	0	0	0	2	0		0	0	0		1	0	0
2007	9	0	0	1	0	0	2	0		0	0			0	0	
2008	2	0	0	5	0	0	0	0		0	0	0		2	0	0
2009	1	0	0	3	0	0	2	0		0	0	0		2	0	0
2010	2	0	0	0	0	0	0	0		0	0	0		0	0	0

Silver Chub has been collected in Lake St. Clair only since 1968. By 1975, abundance began to increase in Lake St. Clair based on OMNR index trawling data for the period 1968–1984 (Figure 10). Dramatic increases were recorded between 1981 and 1984 (approximately 60–200 individuals per trawl-hour), the last years of the index trawling program (S. Nepszy, pers. comm. 2000, cited in Mandrak and Holm 2001). An OMNR beach seine study conducted in Lake St. Clair in 1979 to 1981 and 1990 to 1996 documented high numbers of Silver Chub in 1979 and moderate numbers in 1980, 1981, and 1990. During 1991 to 1996, only a single individual was recorded in 1994. OMNR beach seine surveys in 2005, 2007, 2008, 2009, and trawling in 2010 failed to capture any Silver Chub (Table 1).

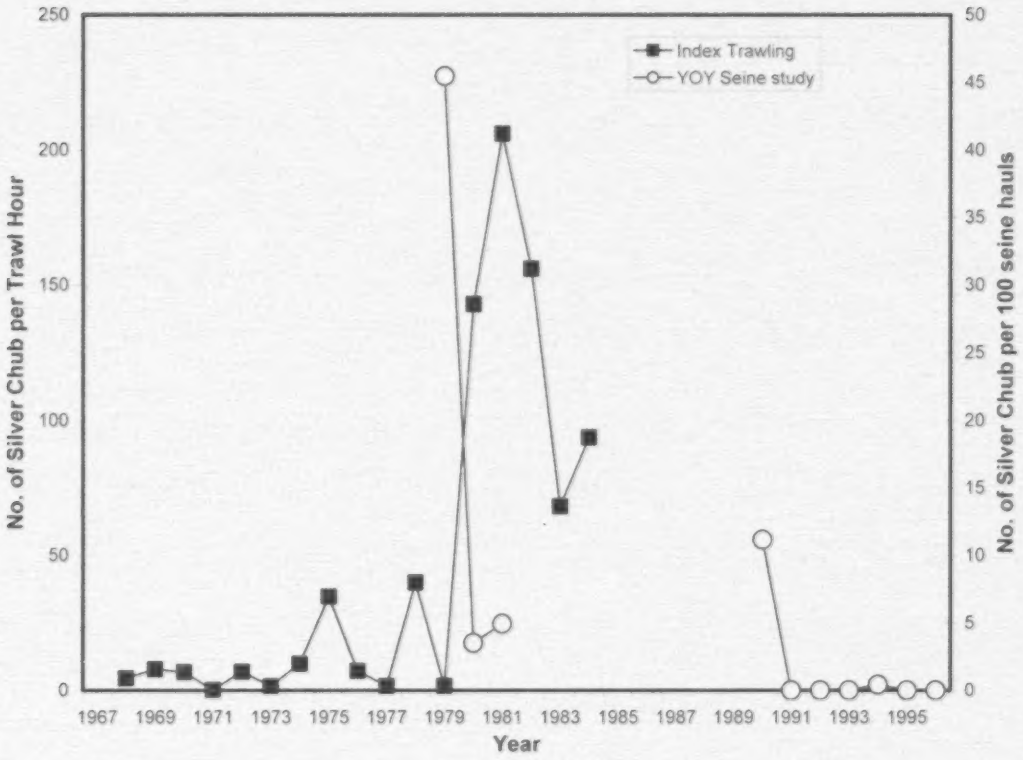

Figure 10. Silver Chub captures in OMNR trawling and young of the year seining in Lake St. Clair, 1968–1996.

There is no evidence that the species naturally exhibits extreme fluctuations since the observed trends in abundance are much longer than the generation time, and do not vary substantially on an annual scale, as would be expected if recruitment fluctuates substantially. The direct causes of the trends observed are not understood but are clearly not due to natural intrinsic demographic processes.

DU2 – Saskatchewan-Nelson River Biogeographic Zone

Sampling Effort and Methods

A summary of sampling efforts and methods since 1994 is included in Table 1, modified from Boyko and Staton 2010.

Abundance

No abundance estimates are available for Silver Chub in Manitoba.

Fluctuations and Trends

Silver Chub distribution in the Red River appears to be stable as recent collections in 2009 (Watkinson, unpublished data; B. Parker, pers. comm. 2010) confirmed the distribution still extends from the United States border to Lake Winnipeg.

In the Assiniboine River, Silver Chub has historically been collected in low numbers at a limited number of sample locations. This is likely an artifact of sampling gear and effort prior to the 2000s. In the 2000s, its range was extended more than 500 river kilometres upstream (Figure 4) (Watkinson, unpublished data).

Silver Chub has been collected at only three sites in the Lake Winnipeg drainage since 1984, despite sampling of known localities dating back to 1954. Annual pelagic trawling surveys of Lake Winnipeg, conducted since 2002 by the Manitoba Water Stewardship, the Lake Winnipeg Consortium, and DFO, have not detected Silver Chub. Abundance in Lake Winnipeg is likely low and the population trend is unknown.

Silver Chub populations appear to be stable in the Assiniboine and Red rivers based on distribution and catch data.

Rescue Effect

The Great Lakes and Manitoba Red River populations are geographically isolated from each other and from other Silver Chub populations that occur in the Mississippi River drainage. The extent of Silver Chub movement within Lake Erie (e.g. across the International boundary) and between Lake Erie and Lake St. Clair is unknown but likely occurs. Therefore, rescue effect within Lake Erie and between the lakes is possible, but unlikely given similar recent declines in American waters (Figure 9).

Silver Chub in the North Dakota and Minnesota portions of the Red River can move into Canada as there are no barriers to movement. The Assiniboine River population is segmented by the Portage Diversion dam. It acts as an upstream barrier to all fish species. The St. Andrews Lock and Dam at Lockport on the Red River is likely a barrier to upstream movement by Silver Chub. A fish ladder is present; however, Silver Chub are not likely to use it.

THREATS AND LIMITING FACTORS

Factors limiting the abundance of Silver Chub include habitat degradation, water temperature, sediment and nutrient loading, exotic species, altered coastal processes, climate change, and baitfish harvesting. Kinney (1954) stated that it requires water temperatures of 7.2–10°C for six to seven months and 21°C for three months to sustain normal growth and permit reproduction. Although the Silver Chub has been recorded from turbid rivers, Trautman (1981) noted that it moved into cleaner water and gravelly substrates when pools became excessively silted. The Silver Chub is tolerant of brackish water (6.5 ppt surface and 9.4 ppt bottom) (Boschung 1992).

The causes for the near extirpation of Silver Chub in Lake Erie in the 1960s and the declines since 2001 are not clear. Eutrophication and its effects on water quality (i.e. low oxygen levels) and on the invertebrate food supply are likely related. Phosphorus loading levels in Lake Erie have gradually levelled off to about 10,000 tonnes in the 1980s from a high of 29,000 tonnes in 1968 (S. Nepszy, pers. comm. 2000, cited in Mandrak and Holm 2001). *Hexagenia* and Silver Chub populations recovered shortly after the introduction of the Zebra Mussel in 1988 (Krieger *et al.* 1996). Predators of the Silver Chub include the Walleye (*Sander vitreus)*, Yellow Perch (*Perca flavescens),* and Burbot (*Lota lota*) (Scott and Crossman 1973). In Lake Erie, Walleye populations generally declined between 1990 and 2004 (Kayle 2009), Yellow Perch generally declined from 1975 to the mid-1990s, then steadily increased to 2004 (Kayle 2009). Burbot had been steadily increasing since 1975 (Stapanian 2009), but have experienced a dramatic decline in recent years due to failed recruitment from 2002 to 2007 (Stapanian *et al.* 2010). In addition, Burbot occur primarily in the eastern basin. The changing predator-prey dynamics involving Yellow Perch and Walleye may be influencing Silver Chub abundance in Lake Erie.

Threats identified in the Silver Chub Management Plan (Boyko and Staton 2010) are included in Table 2. The following descriptions have been adapted primarily from the Essex-Erie Recovery Strategy (EERT 2008).

Habitat Degradation

Modification of inland watercourses through subsurface and surface drainage activities has negatively affected hydrological networks and reduced the extent and quality of aquatic habitat. The species' historical spawning habitat (clean gravel substrates) within tributaries of Lake Erie has become degraded, and it is believed that the species no longer utilizes these areas (Goodyear *et al.* 1982; ERRT 2008).

Nutrient Loadings

Nutrients (nitrates and phosphates) enter water bodies through a variety of pathways, including: manure and fertilizer applications to farmland; manure spills; sewage treatment plants; and faulty domestic septic systems. Nutrient enrichment of waterways can negatively influence aquatic health through algal blooms and associated

reduced dissolved oxygen concentrations. The Silver Chub was almost lost from Lake Erie in the 1960s, likely as a result of eutrophication and associated low oxygen levels that negatively impacted water quality and the invertebrate food supply for the Silver Chub (Mandrak and Holm 2001). Phosphorus loadings reached a high of 29,000 tonnes in 1968, resulting in a collapse in *Hexagenia* spp. populations. As a result of improved water quality in the late 1980s, *Hexagenia* spp. populations recovered and, in 2004, the mean density of *Hexagenia* spp. in western Lake Erie was 195 nymphs/m^2, which is close to the density range of Excellent (201–300 nymphs/m^2), set by Ohio's Lake Erie Quality Index (OLEC; Krieger *et al.* 2007). Phosphorus levels in Lake Erie showed a significant overall downward trend from 1976 to 1999 (Nicholls *et al.* 2001). However, data from 2000 to 2004 suggest a continued increasing trend in phosphorus since 1994 at a rate of approximately 1.4 µg/L/year; the underlying reasons for this increase in phosphorus are unknown (U.S. EPA 2010).

In the Assiniboine and Red rivers of Manitoba, a major concern is non-point source nutrient enrichment from agricultural runoff as well as the hog industry, with high density hog farms throughout the watersheds of the Assiniboine and Red rivers (Manitoba Conservation 2000). Significant increases in total nitrogen and phosphorus have occurred in the Assiniboine and Red river drainages in the past 30 years; increases ranged from 29 to 62% for total phosphorus, and from 54 to 57% for total nitrogen in the Red and Assiniboine rivers, respectively (Jones and Armstrong 2001). These two nutrients are major contributors to nutrient enrichment of water bodies that can result in water quality degradation or eutrophication. Nutrient inputs into these two watersheds have resulted in the eutrophication of Lake Winnipeg. The impact of eutrophication on Silver Chub populations in Manitoba is unknown.

Sediment Loadings

Sediment loadings affect inland watercourses, coastal wetlands, and nearshore habitats through decreasing water clarity, increasing siltation of substrates, and may have a role in the selective transport of pollutants including phosphorus. Sediment loading can result in increased turbidity which can affect a species' vision and respiration. Excess sediment loadings are also related to siltation of substrates, which affect many species at risk and their habitats. Siltation can potentially impact a species through decreasing prey abundance as well as smothering eggs laid on the substrate. Although the Silver Chub has been captured from turbid rivers, it moved to cleaner water with gravel substrates when pools became excessively silted (Trautman 1981), and according to Robison and Buchanan (1992) the species reached its greatest abundance over clean, silt-free, substrates of sand and gravel. The impacts of high sediment loads on the Silver Chub in Canada are not fully understood. It seems likely that the species is more tolerant of high levels of suspended solids (i.e., turbidity), compared to high levels of sediment deposition, given that the species has been caught in the turbid (Secchi depths of 10–30 cm are not uncommon) Assiniboine and Red rivers.

Exotic Species

Exotic species may affect species at risk through several different pathways, including direct competition for space and habitat, competition for food, and restructuring of aquatic food webs (EERT 2008). There are now at least 182 exotic species that have invaded the Great Lakes basin since 1840 (Ricciardi 2006) and at least some of these species will affect species at risk populations to some extent. Dextrase and Mandrak (2006) indicated that while habitat loss and degradation is the predominant threat affecting aquatic species at risk, exotic species are the second most prevalent threat, affecting 26 of 41 federally listed species across Canada. The Common Carp (*Cyprinus carpio*), Round Goby (*Neogobius melanostomus*) and Zebra Mussel are three exotic species that have had a dramatic effect on many aquatic species at risk and will continue to alter ecosystems and ecosystem processes. The Round Goby may negatively impact the Silver Chub through competition for food resources, as *Hexagenia* spp., the preferred prey of the Silver Chub, can also be an important food item for the Round Goby (French and Jude 2001). Krieger *et al.* (2007) suggested that predation by the Round Goby may be limiting the abundance of *Hexagenia* spp. in Lake Erie. This has the potential to negatively impact Silver Chub, given that Johnson *et al.* (2005) estimated the Round Goby population to be 9.9 billion individuals in the western basin in 2002. It is also possible that the Round Goby may feed on Silver Chub eggs or larvae. In general, Round Goby have been found to have a strong negative impact on benthic fishes (French and Jude 2001). Possible impacts of Zebra Mussel on the Silver Chub are not known, but it is possible that the Silver Chub has benefited from the presence of the Zebra Mussel, as populations of both Silver Chub and its prey, *Hexagenia* spp., recovered shortly after the introduction of the Zebra Mussel in Lake Erie (Krieger *et al.* 1996), and dreissenid mussels have been found in the gut contents of Silver Chub (Mandrak, unpublished data). Reasons for the recovery of *Hexagenia* spp. are not fully understood; however, increasing water clarity as a result of the high filtering capability of Zebra Mussels, allowed increased light to penetrate great depths, thereby increasing benthic productivity (Fahnenstiel *et al.* 1995). This increase in benthic productivity may be one factor behind the re-colonization of Lake Erie by *Hexagenia* spp.

White Perch has been present in Lake Erie since the 1950s, likely as a result of dispersal into Lake Ontario through the Erie Canal and, subsequently, into Lake Erie through the Welland Canal (Scott and Crossman 1973). It became abundant by the late 1980s in commercial catches, dropped in abundance in the mid-1990s, rose again by the late 1990s, then dropped in the early 2000s (Kayle 2009). Trawl surveys in the western basin are frequently dominated by juvenile White Perch, a species which preys on benthic invertebrates including mayfly nymphs (A. Cook, OMNR unpubl. data). This invasive species, along with prolific, native Yellow Perch and Walleye, have the potential to suppress Silver Chub abundance through competition and possibly predation.

In Manitoba, the Silver Chub has an overlapping distribution with exotic species that could impact habitat (Common Carp) or be predators of Silver Chub (White Bass (*Morone chrysops*), Smallmouth Bass (*Micropterus dolemieu*), and Largemouth Bass (*Micropterus salmoides*)). The effect of these exotic species on Silver Chub is unknown.

Altered Coastal Processes

The alteration of natural coastal processes through the hardening of shorelines and other activities such as sand and gravel mining has been suggested as a threat for species at risk fishes, including the Silver Chub (EERT 2008). The extent to which this impacts the Silver Chub is currently unknown as the species is believed to spend the majority of time offshore in open water areas.

Climate Change

Climate change is expected to have significant effects on aquatic communities in Canada through several mechanisms including increases in water and air temperatures; changes in water levels; shortening of the duration of ice cover; increases in the frequency of extreme weather events; emergence of diseases; and shifts in predator-prey dynamics (Lemmen and Warren 2004). It is possible that climate change may have an impact on the species through shifts in water temperatures. Warmer water temperatures in DU2 may allow the species to expand its range into the north basin of Lake Winnipeg and the Nelson River.

Climate change may also impact *Hexagenia* spp., the preferred prey of Silver Chub. *Hexagenia* spp. are sensitive to hypoxia (low dissolved oxygen levels; Krieger *et al.* 1996, 2007) and chronic hypoxia, at temperatures of ≤14°C, has been shown to reduce the survival rates of mayfly nymphs (20% survived for 8 days in hypoxic conditions), and this effect is increased at higher water temperatures (Krieger *et al.* 1996). Persistent hot conditions or unusual weather conditions, which permit the establishment of a shallow hypolimnion over large areas of the western basin of Lake Erie, could lead to anoxic (lack of dissolved oxygen) conditions at the bottom of the lake (Krieger *et al.* 1996); this would likely have a negative impact on *Hexagenia* spp. populations. It is anticipated that the effects of climate change will be widespread and should be considered a contributing impact to species at risk and all habitats. Identifying mitigation measures to adapt and prevent negative implications as a result of climate change will require coordination with other agencies for research, recommended mitigation measures and monitoring.

Baitfish Harvesting

Baitfish harvesting is regulated in Manitoba with "bait fish" defined in Schedule 1 under the (federal) Manitoba Fishery Regulations, 1987, to include "Minnows, except carp and goldfish", which would make the Silver Chub a legal baitfish species. Currently, there are eight commercial baitfish harvesters licensed on the Red River who seine for baitfish. There are also eight harvesters licensed for the Lake Winnipeg south basin; however, production in the lake proper is low, and is most likely confined to harvesters seining areas near shore, particularly near the mouth of the Red River or other rivers flowing into the lake. In some cases, baitfish harvesters are also commercial fishers who use their baitfishing licence to market incidental catch of small Cisco (*Coregonus artedi*). No studies have been conducted on harvested baitfish to determine the occurrence of Silver Chub.

The Silver Chub is not a legal baitfish in Ontario (OMNR 2010). Incidental harvest as a result of commercial fishing has been described as a potential threat to the Silver Chub (Mandrak and Holm 2001); however, the minimum mesh size of commercial gill nets in Lake Erie is 57 mm, and during OMNR surveys, 99% of Silver Chub were caught in mesh sizes less than 57 mm (M. Belore, pers. comm. 2007 cited in Boyko and Staton 2010). Therefore, incidental catch from commercial operations in Ontario is not likely to present a serious threat to the Silver Chub. Similarly, incidental harvest is not considered a threat to populations in Manitoba where the minimum commercial gill net size is 76 mm (D. Kroeker, pers. comm. 2010).

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Silver Chub was first assessed in 2001 by COSEWIC as Special Concern. The Committee on the Status of Endangered Wildlife in Canada considered it a single unit and designated it Special Concern in April 1985. The status was re-examined and confirmed in May 2001. In May 2012, the "Great Lakes - Upper St. Lawrence populations" unit was designated Endangered in May 2012 and the "Saskatchewan - Nelson River populations" unit was designated Not at Risk. This species is listed under the federal *Species at Risk Act* (SARA) and has been protected under the SARA as of June 2004. Additional protection is given through the federal *Fisheries Act*. A management plan has been developed for the Silver Chub through the SARA (Boyko and Staton 2010), and it is addressed in the Essex-Erie Region Fishes at Risk Recovery Strategy (EERT 2008). The Silver Chub is listed as Special Concern under the province of Ontario's *Endangered Species Act, 2007*. The Silver Chub is not a legal baitfish in Ontario (OMNR 2010).

Non-Legal Status and Ranks

Although the Silver Chub is not protected under the United States *Endangered Species Act*, it is protected by several states including Illinois, Kansas, Michigan, and New York. The following ranks apply to the conservation status of the Silver Chub (NatureServe 2010):

Global status: G5 (Secure)
National Status: N3 (Vulnerable)
Ontario Status: S2 (Imperiled)
Manitoba Status: S3 (Vulnerable)

Habitat Protection and Ownership

In Canada, the habitat of Silver Chub and all fishes is protected under the federal *Fisheries Act*. The federal *Fisheries Act* prohibits destruction of fish habitat. In Ontario, few, if any, parks and conservation areas have been established specifically to preserve aquatic biodiversity. However, some actually do protect aquatic biodiversity as a result of their location and management practices (Mandrak and Brodribb 2005). Rondeau Provincial Park in Ontario and Hecla, Spruce Woods, and Portage La Prairie provincial parks in Manitoba may serve to protect the Silver Chub.

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Douglas Watkinson is a Research Biologist with Fisheries and Oceans Canada in Winnipeg. He has sampled fish in many of the major river systems of the Hudson Bay drainage from northwestern Ontario west to the Rockies. His current research focuses on species at risk, habitat impacts, and aquatic invasive species. He has co-authored four COSEWIC reports and the field guide The Freshwater Fishes of Manitoba.

Mary Burridge is an Assistant Curator of Ichthyology in the Department of Natural History, Royal Ontario Museum. With more than 30 years of experience, she has written numerous scientific papers describing new fish species from Southeast Asia and the Indo-Pacific. She has also written popular articles on issues affecting Ontario's native species, and the ROM's exhibitions and collections. Mary is a team member of the ROM's Water Exhibition, the Life in Crisis-Schad Gallery of Biodiversity, and the Patrick and Barbara Keenan Family Gallery of Hands-on Biodiversity. She is also active in outreach programs, visiting schools and youth groups to advocate Ontario's native biodiversity.

Erling Holm is Assistant Curator of Ichthyology in the Department of Natural History, Royal Ontario Museum. His interests include the taxonomy and ecology of Canadian freshwater fishes. Since 1986, he has focused on fishes at risk and has co-authored 11 status reports. He manages one of Canada's largest fish collections, conducts fieldwork in Ontario, and coordinates the ROM's annual fish identification workshops. He co-authored the ROM Field Guide to Freshwater Fishes of Ontario.

COLLECTIONS EXAMINED

No collections were examined in preparing this report.